

Amphibians of the Sikkim Himalaya, India: an annotated checklist

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Abstract: We present an annotated list of amphibians for the state of Sikkim, India. Data were obtained through literature reviews, fieldwork and review of museum collections. Forty-four species of amphibians belonging to 20 genera in eight families and three orders have been reported in Sikkim from 1864 to 2015. During our fieldwork, we recorded 23 species, of which two are new records for the state.

Key words: species inventory; new records; updated list; identification; Eastern Himalaya

INTRODUCTION

India is bestowed with four global hotspots of biological diversity: the Western Ghats, the Himalaya, the Indo-Burma hotspot (northeast India), and the Sundaland hotspot (Andaman and Nicobar Islands) (MITTERMEIER 2011). The state of Sikkim is associated with the Himalayan biodiversity hotspot and has a rich flora and fauna owing to the presence of diverse altitudinal, climatic, and vegetation gradients. Sikkim has long been of interest to naturalists because it presents a range of ecosystems from the dense tropical forests and alpine grasslands to the cold desert. Historically, Sikkim was a small kingdom, but in 1975, it was annexed to India and became a state. Sikkim has a rich history of natural history exploration, with expeditions as early as the 1840s (CAMPBELL 1840; TICKELL 1843; HOOKER 1849; GRAY 1854).

The first to write about amphibians of Sikkim was GÜNTHER (1864). BOULENGER (1890) later reported 21 species of amphibians from Sikkim, Darjeeling, and other parts of the Himalaya, as well as 11 species exclusively from Sikkim. GAMMIE (1928) reported 16 amphibian species from Sikkim based on BOULENGER's (1890) earlier work. SWAN & LEVITON (1962) reported 27 species from the Sikkim–Darjeeling region, and WALTNER (1975) recorded 30 species from Darjeeling and Rungeet valley (British Sikkim). Recently, INGER & DUTTA (1986) reported 12

species, LACHUNGPA (1998) reported 13 species, CHANDA (2002) reported 14 species, JHA & THAPA (2002) reported 27 species of amphibians in Sikkim. The majority of these publications were compilations of previous literature. Most recently, CHETTRI (2007) reported 23 species from Teesta Valley and the Maenam Wildlife Sanctuary in Sikkim.

However, after recent additions to the amphibian fauna of Sikkim, an updated comprehensive checklist of the amphibians of Sikkim is needed. The list of species is based on species records taken during two years of field survey in Sikkim and an exhaustive review of literature published between 1864 and 2015. This annotated list will provide a baseline for future research on amphibians in this region.

MATERIALS AND METHODS

Study site

The state of Sikkim (7,096 km²) lies between 27°05'N to 28°07'N and 87°59'E to 88°56'E and is bordered to the north, west, and east by China, Nepal, and Bhutan, respectively. The elevation range extends from 230 m to 8,598 m above sea level. Although having a small area, Sikkim has a rich biodiversity, harboring 574 species of birds, 689 species of butterflies, and approximately 4,500 species of flowering plants (ARRAWATIA & TAMBE 2011).

The large altitudinal range and relatively steep slopes has given rise to several eco-climatic zones, and the amphibian species in this checklist are restricted to specific altitudinal and eco-climatic zones.

The state is roughly divided into tropical, temperate, and alpine zones, and experiences three seasons: summer (March to May); monsoon (June to October); and winter (November to February). Temperatures vary with altitude and aspect, with seasonal highs recorded during July and August, and seasonal minimums during December and January. Summer temperatures range from a maximum of 27.5°C to a minimum of 13.1°C and the winter temperatures vary from maximum of 14.9°C to minimum of

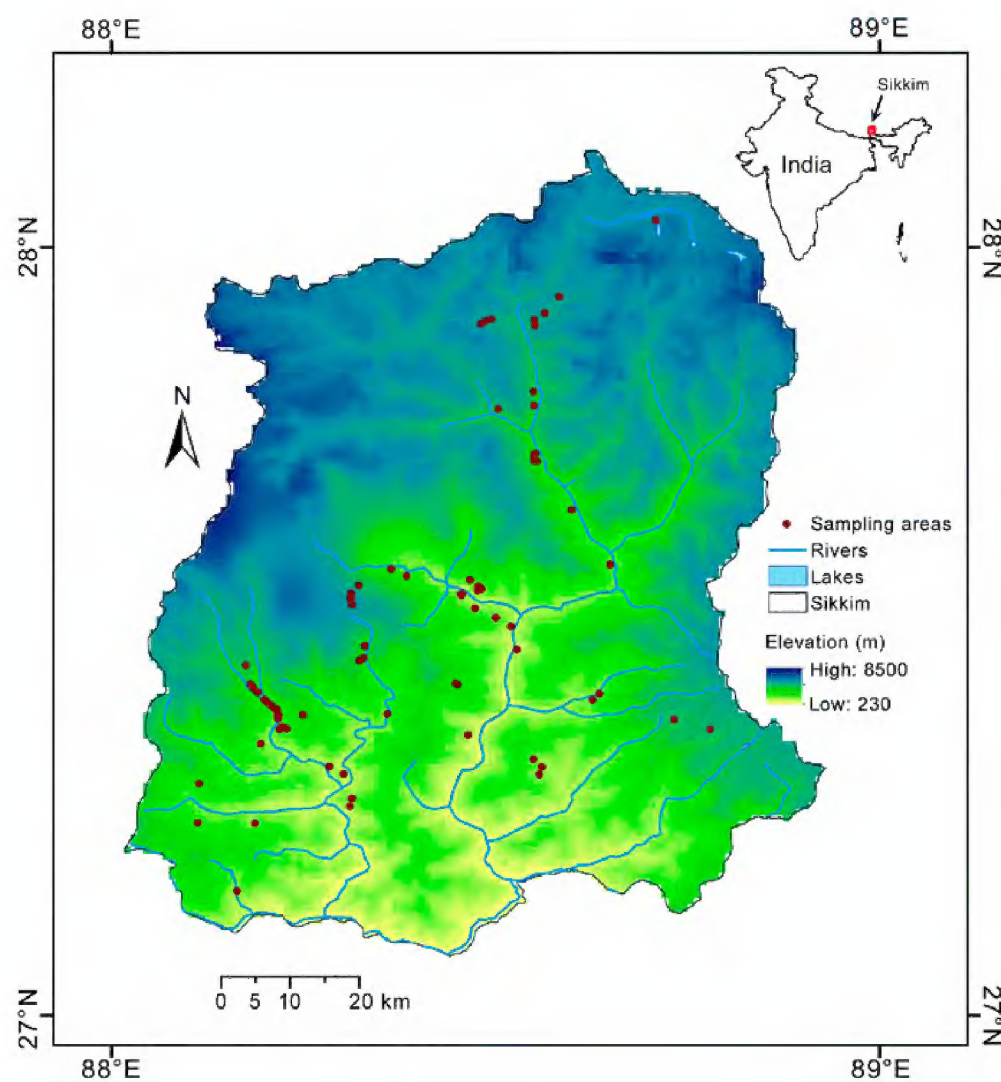


Figure 1. Sampling localities recorded between 2012 to 2013 in Sikkim, India.

1.5°C. At higher altitudes, the temperature can be as low as -30°C. Sikkim receives the southwest monsoon during June to October, with July being the wettest month. The average per annum rainfall ranges from 1200 mm to 3200 mm (TAMBE et al. 2012).

Habitat types include agricultural land, mesic forests, scrub forests, streams, stream-fed marshes, grasslands, and cold desert lakes.

Data collection

The checklist is based on three sources:

- 1) Field surveys from April to October in 2012 and 2013 (Figure 1). Intensive surveys were conducted as a part of a larger study on community ecology of amphibians of Sikkim Himalaya. Transects along the streams, visual encounter surveys (VES), and acoustic censuses were undertaken.
- 2) Literature review of journals, books, and reports.
- 3) Review of the collection of amphibians in the Zoological Survey of India (ZSI), Kolkata.

Synonyms were removed and taxonomy of the checklist was updated following FROST et al. (2016) and DINESH et al. (2015a, 2015b). The Red List category (IUCN 2016) of each species is included.

We used photographs as vouchers of our observations in the field; only those species that are new records for the state and those with doubtful presence records were collected (permit no. 15/DIR(REE)/FEWMD/GOS/2011). The photographs were deposited in Ashoka Trust for

Research in Ecology and the Environment (ATREE) digital image collection and Sikkim Forest Department. The specimens are deposited in Zoological Survey of India (ZSI), Kolkata, India.

RESULTS

Forty-four species of amphibians belonging to 20 genera, in eight families and three orders, are known from Sikkim (Table 1). Included are 43 frogs and toads, three caecilians, and a salamander.

We observed 23 species during our fieldwork in 2012 and 2013. Of these 23 species, *Duttaphrynus stuarti* and *Fejervarya nepalensis* are new records for the state.

The following species were encountered during our fieldwork.

Family Bufonidae Gray, 1825

Duttaphrynus himalayanus (Günther, 1864) (Figure 2)

Measurements: SVL, male: average 77 mm (Nanhoe and Ouboter 1987); female: maximum 127 mm (Günther 1864). Specimens from Sikkim, male: 58.4–90.1 mm ($n = 20$); female: 88.3–129.5 mm ($n = 15$).

Diagnostic characters: Crown deeply concave, head wider than long. Snout short and blunt. Tympanum very small, almost indistinct. Parotoids elongate, elliptical and prominent. Fingers free, I–II and II–III toes are fully webbed. Irregular porous warts present on the dorsum. In some specimens, warts on the limbs and adjacent to the jaw keratinized. Small warts present on the ventral side. Dorsal color varies from greyish to dark brown or yellowish brown. Ventral part yellowish to greyish, marbled with dark grey in some specimens.

References: GÜNTHER (1864); BOULENGER (1882); SHRESTHA (2001); SHAH & TIWARI (2004).

Duttaphrynus melanostictus (Schneider, 1799) (Figure 3)

Measurements: SVL, male: average 57 mm; female: average 64 mm (Nanhoe and Ouboter 1987). Specimens from Sikkim, male: 55–60.2 mm ($n = 15$); female: 59–110 mm ($n = 21$).

Diagnostic characters: Head with more-or-less elevated cranial ridges, which include a canthal, preorbital, post orbital, and supraorbital ridge. Tympanum very distinct, round or oval. Parotoids very prominent, kidney-shaped or elliptical. Cranial ridges, tips of warts and upper jaw rim are black. Fingers free, toes ½-webbed. Small to medium-sized warts present on the dorsum, ventral part granular. Dorsal color varies from yellowish to brownish or beige to greyish. Some specimens may be brick red during reproductive period (SCHLEICH & KÄSTLE 2002). Venter is uniformly cream-colored with spots on the thoracic and gular regions.

References: NANHOE & OUBOTER (1987); DUBOIS & OHLER (1999); SCHLEICH & KÄSTLE (2002).

Table 1. Amphibians of Sikkim. Conservation status: according to International Union for Conservation of Nature (IUCN); LC = Least Concern, DD = Data Deficient, NT = Near Threatened, VU = Vulnerable and NE = Not Evaluated. Reference: first publication to report species from Sikkim. Observed: species observed by the authors in the field. Remarks: Notes on taxonomy and occurrence.

Taxon	IUCN			Reference	Remarks
Class Amphibia					
Order Anura					
Family Bufonidae					
<i>Duttaphrynus himalayanus</i> (Günther, 1864)	LC	✓		GÜNTHER (1864)	The type locality of the species as per GÜNTHER (1864) is “Himalayas (in Sikkim and Nepal).”
<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	LC	✓		BOULENGER (1890)	According to GÜNTHER (1864), “in the Himalayas it ascends to an altitude of 9000 feet.” Later, BOULENGER (1890), reported the species from “Sikhim Himalayas” up to a elevation of about 10,000 feet.
<i>Duttaphrynus stuarti</i> (Smith ,1929)	DD	✓		This study	New record from Sikkim. The type locality of this species is “Putao plain, N.E. Burma, near the Tibetan frontier”, Myanmar. In India, it is reported from Arunachal Pradesh (AGARWAL & MISTRY 2008) and Meghalaya (MATHEW & SEN 2010). The specimen from this study is deposited in ZSI, India (ZSI A13424).
Family Dicroglossidae					
<i>Euphlyctis cyanophlyctis</i> (Schneider, 1799)	LC	X		SWAN & LEVITON (1962)	BOULENGER (1890) reported the occurrence of this species in the Himalayas upto 6000 ft, but did not explicitly mention its presence in Sikkim. Later, SWAN & LEVITON (1962) reported it from Sikkim–Darjeeling region.*
<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	None	X		BOULENGER (1890)	GÜNTHER (1864) mentioned having received specimen from “Himalayas (Jamu)”, later BOULENGER (1890) reported the species from Sikkim. <i>Fejervarya limnocharis</i> contains several cryptic species (DUBOIS & OHLER 2000). On the basis of molecular and morphological studies the populations with the name <i>F. limnocharis</i> are in Indonesia, Malaysia, Thailand, Laos and Cambodia, and populations from outside of these region with the name certainly apply to other species (McKAY 2006; DJONG 2007; KOTAKI et al. 2008; KOTAKI et al. 2010; SUMARLI et al. 2015). New record; specimen deposited in ZSI, India (ZSI A14153).
<i>Fejervarya nepalensis</i> (Dubois, 1975)	LC	✓		This study	CHETTRI (2011) reported this species from Sikkim.
<i>Fejervarya teraiensis</i> (Dubois, 1984)	LC	✓		CHETTRI (2011)	BOULENGER (1890) reported its presence from the base of the Himalaya. Later, SWAN & LEVITON (1962) reported it from Sikkim–Darjeeling region.*
<i>Hoplobatrachus tigerinus</i> (Daudin, 1802)	LC	✓		SWAN & LEVITON (1962)	First described by BOULENGER (1882), the type locality of the species is Sureil, 5500 ft, Suchal [= Senchal] Waterworks, near Ghoom, and Peshok, alt. 4500 ft, Darjeeling, West Bengal, India. This species was first reported from the Sikkim–Darjeeling region by SWAN & LEVITON (1962).*
<i>Nanorana annandalii</i> (Boulenger,1920)	NT	✓		SWAN & LEVITON (1962)	The specimen collected from this study is deposited in ZSI, India (A14151).
<i>Nanorana blanfordii</i> (Boulenger, 1882)	LC	✓		SWAN & LEVITON (1962)	First described by BOULENGER (1882), the type locality of the species is Darjeeling, West Bengal, India. SWAN & LEVITON (1962), reported this species from Sikkim–Darjeeling region.* The specimen collected from this study is deposited in ZSI, India (ZSI A13428).
<i>Nanorana ercepeae</i> (Dubois, 1974)	NT	X		SCHLEICH & KASTLE (2002); CHETTRI (2011)	Its present distribution is western Nepal. SCHLEICH & KASTLE (2002) and CHETTRI (2011) reported this species from Sikkim, no museum records were provided by these authors.
<i>Nanorana gammii</i> (Anderson, 1871)	NT	✓		SWAN & LEVITON (1962)	This species was described by ANDERSON (1871), type locality is Darjeeling at 4000 feet. In his note he also mentions that he has no way of determining whether <i>R. sikimensis</i> (<i>Ombrawa sikimensis</i>) described by JERDON (1870), is the same as this particular species. SCHLEICH & KASTLE (2002) has treated these two species as synonymous. SWAN & LEVITON reported this species from Sikkim–Darjeeling region.* The specimen collected from this study is deposited in ZSI, India (ZSI A13429,ZSI A13430) under the name <i>Nanorana gammii</i> .
<i>Nanorana liebighi</i> (Günther, 1860)	LC	✓		BOULENGER (1890)	It is presently reported from W Nepal (SCLEICH & KASTLE 2002; SHAH & TIWARI 2004) and Uttar Pradesh and Himachal Pradesh in India (MEHTA 2005). CHETTRI (2011) reported it from Sikkim but no museum record was provided.
<i>Nanorana minica</i> (Dubois, 1975)	VU	X		CHETTRI (2011)	The type locality of this species is “Langtang Village” in Nepal (SMITH 1951). WALTNER (1973) added Darjeeling and Sikkim in its distribution range although these regions were not mentioned in any of the literatures cited by WALTNER (SMITH 1935–1943; SWAN 1947; SWAN & LEVITON 1962). Further work required to confirm the presence of this species in Sikkim.
<i>Nanorana polunini</i> (Smith, 1951)	LC	X		WALTNER (1973)	Presence in Sikkim probable. Previously recorded from Arunachal Pradesh (ANNANDALE 1912), Nagaland (Ao et al.2003), Meghalaya (MATHEW & SEN 2003), Mizoram (SAILO et al. 2009) in northeast India, Bangladesh (REZA 2008), Myanmar (WOGAN et al. 2008) and China (ZHAO & ADLER 1993). CHETTRI (2011) reported its presence in Sikkim, but no museum record was provided.
<i>Ingerana borealis</i> (Annandale, 1912)	LC	X		CHETTRI (2011)	See remarks on <i>Nanorana gammii</i>
<i>Ombrawa sikimensis</i> (Jerdon, 1870)	LC	✓		INGER & DUTTA (1986)	BOULENGER (1890) reported this species from Himalayas upto 7000 ft, but did not explicitly mention its presence in Sikkim. Later, SWAN & LEVITON (1962) reported it from Sikkim–Darjeeling region,* probably based on Boulenger’s report, but museum records were not provided.
<i>Sphaerotheca breviceps</i> (Schneider, 1799)	LC	X		SWAN & LEVITON (1962)	
Family Microhylidae					
<i>Microhyla ornata</i> (Duméril & Bibron, 1841)	LC	X		CHANDA (2002)	CHANDA (2002) reported this species from Sikkim, but museum records were not provided.

Continued

Table 1. Continued.

Taxon	IUCN			Reference	Remarks
	status	Observed			
Family Megophryidae					
<i>Megophrys boettgeri</i> (Boulenger, 1899)	LC	X		MATHEW & SEN (2010)	This species was first reported from Sikkim by MATHEW & SEN (2010), but no museum record was provided. The type locality of the species is Kuatun village in China. This species is removed from the Indian amphibian list (MAHONY et al. 2013).
<i>Megophrys major</i> Boulenger, 1908	LC	X		SWAN & LEVITON (1962)	First described by JERDON (1870), the type locality of the species is "Darjeeling", West Bengal, India. It was reported from the Sikkim–Darjeeling region by SWAN & LEVITON (1962).*
<i>Megophrys parva</i> (Boulenger, 1893)	LC	✓		GÜNTHER (1864)	This species was first reported by GÜNTHER (1864) from Sikkim. The type locality of the species is Sikkim and Khasi hills. Specimen collected from the present study is deposited in ZSI, India (ZSI A13431)
<i>Megophrys robusta</i> Boulenger, 1908	DD	✓		JHA & THAPA (2002)	JHA & THAPA (2002) reported the presence of this species from Sikkim. The type locality of this species is "Darjeeling", West Bengal, India.
<i>Scutiger boulengeri</i> (Bedriaga, 1898)	LC	✓		SUBBA et al. (2015)	Previously reported from north-central Nepal and southern Xizang to Sichuan, Yunnan, Gansu, and Qinghai in China, 3300–5270 m elevation. Specimen from this study is deposited in ZSI, India (A13421, A13422).
<i>Scutiger sikimensis</i> (Blyth, 1855)	LC	✓		BLYTH (1855)	The species was first described by BLYTH (1855). According to BOULENGER (1872) the original 2 specimens described by Blyth, were obtained by Captain Sherwill from Sikkim and housed in ZSI, India. They were listed by SCLATER (1892) as ZSIC 9854-55. BOULENGER (1872) also reported this species from Sikkim, the specimens were collected by Blanford (Boulenger 1872). Specimen from this study is deposited in ZSI, India. (ZSI A13433).
Family Ranidae					
<i>Amolops afghanus</i> (Günther, 1858)	LC	X		SWAN & LEVITON (1962)	The type locality of this species is stated as Afghanistan in the original description by GÜNTHER (1858), although this claim has been strongly disputed (ANNANDALE 1912; FUTTEN et al. 2012). <i>A. afghanus</i> was placed in the synonymy with <i>A. marmoratus</i> (ANDERSON 1871; MASON 1882; BOULENGER 1882; BOURET 1942; DUBOIS 1992), but has been resurrected from the synonymy by FUTTEN et al. 2012. The first record of this species from India is by BOULENGER (1890) who considered <i>A. afghanus</i> to be conspecific to <i>Rana latopalmata</i> . <i>A. afghanus</i> was first reported from Sikkim–Darjeeling region by SWAN & LEVITON (1962).* This is probably a case of misidentification.
<i>Amolops formosus</i> (Günther, 1875)	NE	✓		SWAN & LEVITON (1962)	SWAN & LEVITON reported the species from the Sikkim–Darjeeling region.* BOULENGER (1890) reported it from Darjeeling. The type locality of the species is "Khassya" (= Khasi Hills), Assam, India.
<i>Amolops gerbillus</i> (Annandale, 1912)	LC	X		SWAN & LEVITON (1962)	SWAN & LEVITON reported the species from the Sikkim–Darjeeling region.* BOULENGER (1890) reported it from Darjeeling (3500 ft). The type locality of the species is "Yembung, Abor foothills at an altitude of 1,100 ft," Arunachal Pradesh, India. Possibly present in Sikkim.
<i>Amolops himalayanus</i> (Boulenger, 1888)	LC	✓		SWAN & LEVITON (1962)	The type locality of the species is Darjeeling, India. SWAN & LEVITON (1962) reported it from the Sikkim–Darjeeling region,* probably based on Boulenger's report.
<i>Amolops marmoratus</i> (Blyth, 1855)	LC	✓		SCHLEICH & KASTLE (2002)	BOULENGER (1890) reported this species from Darjeeling but did not explicitly mention its presence in Sikkim. SCHLEICH & KASTLE (2002) mentioned its presence in Sikkim. The specimen from this study is deposited in ZSI, India (ZSI A13425, ZSI A13426).
<i>Amolops monticola</i> Anderson, 1871	LC	✓		SWAN & LEVITON (1962)	SWAN & LEVITON (1962) reported the species from Sikkim–Darjeeling.* The type locality of the species is Darjeeling, 3500 feet, West Bengal, India. The specimen from this study is deposited in ZSI, India (ZSI A13427).
<i>Clinotarsus alticola</i> (Boulenger, 1882)	DD	X		INGER & DUTTA (1986)	INGER & DUTTA (1986) reported its presence in Sikkim but they have not given the reference for this information. The type locality of the species is "Shillong", Khasi Hills, Meghalaya, northeast India. Probably present in Sikkim.
Family Rhacophoridae					
<i>Polypedates leucomystax</i> (Gravenhorst, 1829)	LC	✓		SWAN & LEVITON (1962); Inger & Dutta (1986)	SWAN & LEVITON reported the species from the Sikkim–Darjeeling region.* INGER & DUTTA (1986) reported it from Sikkim. The specimen from this study is deposited in ZSI, India (ZSI A13432).
<i>Polypedates maculatus</i> (Gray, 1830)	LC	✓		BOULENGER (1890)	BOULENGER (1890) reported this species from Sikkim.
<i>Polypedates megacephalus</i> Hallowell, 1861	LC	X		CHETTRI (2011)	In India, this species is reported from Nagaland (Ao et al. 2003) and Sikkim (CHETTRI 2011).
<i>Raorchestes annandalii</i> (Boulenger, 1906)	LC	✓		SWAN & LEVITON (1962)	BOULENGER (1890) reported this species from eastern Himalaya, but did not explicitly mention its presence in Sikkim.* SWAN & LEVITON (1962) reported this species from the Sikkim–Darjeeling region.
<i>Philautus dubius</i> (Boulenger, 1882)	LC	X		SWAN & LEVITON (1962); WALTNER (1973)	GÜNTHER (1875) described the species as " <i>Ixalus jerdonii</i> "; from a single specimen from Jerdon's collection. But he also expresses his doubt regarding the collection region of the specimen, he writes, "On the bottle it was marked as coming from Darjeeling; but it is possible that it is the same specimen mentioned by Jerdon as having been found by him "in the Khasis". BOULENGER (1890) reported this species from eastern Himalaya, but did not explicitly mention its presence in Sikkim. SWAN & LEVITON (1962) reported this species from the Sikkim–Darjeeling region.* Later WALTNER (1973), reported it from Sikkim and Darjeeling.
<i>Frankixalus jerdonii</i> (Günther, 1876)	DD	X		SWAN & LEVITON (1962)	BOULENGER (1890) reported this species from Darjeeling but did not explicitly mention its presence in Sikkim. SWAN & LEVITON (1947) reported this species from the Sikkim–Darjeeling region.* The type locality of the species is Darjeeling, West Bengal, India.
<i>Rhacophorus maximus</i> Günther, 1858	DD	✓		JERDON (1870)	Reported from Sikkim by JERDON (1870), he has given the type locality of the species as Sikkim and Khasi Hills.

Continued

Table 1. Continued.

Taxon	IUCN status	Observed	Reference	Remarks
<i>Rhacophorus reinwardtii</i> (Schlegel, 1840)	LC	X	JERDON (1870)	JERDON (1870) reported it from Sikkim. BOULENGER (1890) reported this species from eastern Himalaya but did not explicitly mention its presence in Sikkim. Its type locality is Java (Indonesia). Its presence in Sikkim is doubtful.
Order Gymnophiona				
Family Salamandridae				
<i>Tylotriton verrucosus</i> Anderson, 1871	LC	X	BOULENGER (1890)	Several authors (GAMMILL 1928; INGER & DUTTA 1986; WALTNER 1973; SARKAR 1992; CHANDA 2002; JHA & THAPA 2002; MATHEW AND SEN 2010) after BOULENGER (1890) reported the presence of <i>T. verrucosus</i> in Sikkim. Most of the above references are based on published papers. The presence of Himalayan salamander in Sikkim remains doubtful.
Order Urodela				
Family Ichthyophidae				
<i>Ichthyophis glutinosus</i> (Linnaeus, 1958)	DD	X	BOULENGER (1890); JERDON (1870)	JERDON (1870) reported this species from Sikkim. BOULENGER (1890) reported it from eastern Himalaya but did not explicitly mention its presence in Sikkim. Its present distribution is Central and Southern Sri Lanka. Its presence in Sikkim is probably a case of misidentification.
<i>Ichthyophis monochrous</i> (Bleeker, 1858)	DD	X	BOULENGER (1890)	BOULENGER (1890) reported this species from Sikkim. The name has been misapplied frequently (TAYLOR 1968). This name was once applied to all species of unstriped Ichthyophis, the species reported from Sikkim is presumably a case of misidentification. Its present distribution is northern Borneo and Sarawak.
<i>Ichthyophis sikkimensis</i> Taylor, 1960	DD	✓	TAYLOR (1960)	Taylor described the type specimen from Darjeeling and paratypes from the Rungeet Valley, British Sikkim.

*SWAN & LEVITON (1962) treated Sikkim–Darjeeling as a single region due to their geographic similarity. Literature referred by SWAN & LEVITON (1962) in their compilation of Himalayan batrachians was BOULENGER (1882, 1907, 1920), GÜNTHER (1864), SMITH (1931, 1935, 1943, 1951, 1953), and an unpublished work of Swan (1947). Later, WALTNER (1973) cited SWAN & LEVITON (1962) in his work on the herpetofauna of the Himalayas, and all the species which SWAN & LEVITON had reported from Sikkim–Darjeeling, WALTNER reported as occurring in Sikkim and Darjeeling.



Figures 2–3. Amphibians of the Sikkim Himalaya, India. 2. *Duttaphrynus himalayanus* (SVL 66.5 mm, male), 27°39'34.41" N, 088°36'11.89" E, 19 June 2013. 3. *Duttaphrynus melanostictus* (SVL 60 mm, female), 27°28'38.90" N, 088°31'46.78" E, 20 May 2013.

Duttaphrynus stuarti (Smith, 1929) (Figure 4)

Measurements: SVL, male/female: 73 mm (SMITH 1929), 71.3 mm (WOGAN et al. 2003). Specimens from Sikkim, male: 52–63.3 mm (*n* = 2).

Diagnostic characters: Head wider than long. Cranial ridges absent. Snout obtuse, protruding beyond mouth. Tympanum distinct, half the diameter of the eye. Tarso metatarsal articulation reaches to the tip of the snout. Parotoid glands prominent, elongate and reniform. Vocal sacs present. Fingers free, toes ¾-webbed. Dorsum granular with numerous keratinized spiculate warts. Ventral side granular. Dorsal coloration olive to brownish, venter whitish to yellowish with dark mottling. Males with nuptial pads on digits I, II and III.

This is a first report of *D. stuarti* from Sikkim.

Voucher specimen: ZSI A 13424

References: SMITH (1929); WOGAN et. al. (2003).



Figures 4–5. Amphibians of the Sikkim Himalaya, India. **4.** *Duttaphrynus stuartii* (SVL 52 mm, male), 27°13'57.25" N, 088°10'59.60" E (SVL 52, male), 28 August 2013. **5.** *Nanorana annandalii* (SVL 33.1 mm, male), 27°13'57.74" N, 088°11'0.42" E, 28 August 13.

Family Dicroglossidae Anderson, 1871

Nanorana annandalii (Boulenger, 1920) (Figure 5)

Measurements: SVL, Male: 41–52mm; female: 46–45 mm (BOULENGER 1920). Specimens from Sikkim, male: 33.1–35.2 mm ($n = 2$); female: 43 mm ($n = 1$).

Diagnostic characters: Head broader than long, depressed. Tympanum small, hidden or indistinct. Prominent supratympanic fold. Dorsum has small warts and granules, dorsolateral fold present on the anterior part of the dorsum. Venter smooth. Dorsal coloration varies from olive to orange brown and the venter is cream to yellowish with spots on the pectoral and lower jaw margin. In males, upper arms are hypertrophied. Keratinized spines are present on the metacarpal tubercle, the dorso lateral region of the first finger and the sides of I to III fingers. A pair of spinous triangular patch is present on the pectoral region.

This is a first verified report of *N. annandalii* from Sikkim.

Voucher specimen: ZSI A 14151

References: BOULENGER (1920); DUBOIS & MATSUI (1983); SCHLEICH & KÄSTLE (2002).

Nanorana blanfordii (Boulenger, 1882) (Figure 6)

Measurements: SVL, male: 32–39 mm; female: 50 mm (BOULENGER 1920). Specimens from Sikkim, male: 37.4–43.2 mm ($n = 15$); female: 42–49.5mm ($n = 12$)

Diagnostic characters: Head scarcely broader than long. Snout rounded, projects slightly beyond the lower jaw. Tympanum indistinct. Supratympanic fold weakly developed. Fingers free, finger tips pointed and toes $\frac{3}{4}$ -webbed with rounded tips. Dorsum smooth or with small granules and flat warts. Ventral side smooth. The dorsal surface has a variable pattern of brown and chestnut with grass-green and olive spots and streaks. Ventral side yellowish. Secondary sexual characters absent in males.

Voucher specimen: ZSI A13428

References: BOULENGER (1920); DUBOIS (2004).

Nanorana gammii (Anderson, 1871) (Figure 7)

Measurements: SVL, male: 63 mm; female: 60.5–88 mm (Dubois 1976). Specimens from Sikkim, male: 62.5–65 mm ($n = 11$); female: 69–82.5 mm ($n = 12$).

Diagnostic characters: Head slightly elongated. Snout and *canthus rostralis* rounded. Distinct supratympanic fold. Tympanum small and indistinct. Fingers with rudimentary webbing. Toes completely webbed without curvature between adjacent toes. Dorsal color olive grey to brownish, a dark band runs through the *canthus rostralis* along the supratympanic and the dorsolateral fold. Venter is yellowish, slightly brighter on the inner thigh and groin area. Presence of granular square dermal flaps above the vent. During the reproductive phase the granules of adult males grow into keratinized spines, white at the base and dark at the tip. Males lack nuptial spines on forelimbs and pectoral region as well as hypertrophied arms.

Comments: *Nanorana gammii* was first described by ANDERSON (1971), who wrote, that he had no way to distinguish his new species from *Rana sikimensis* Jerdon, 1870 (now *Ombrana sikimensis*). JERDON (1870) did not provide a full description of the species. The type locality for both species is Darjeeling at an elevation of 4,000 feet [1219 m]. The validity of *R. sikimensis* is therefore mainly based on conjecture derived from historical texts. SCHLEICH & KÄSTLE (2002) treated *O. sikimensis* and *N. gammii* as synonyms. However, OHLER & DUBOIS (2006), in a new working taxonomy of the tribe Paini, placed *N. gammii* and *O. sikimensis* in separate subgenera of *Chaparana* Bourret, 1939 and *Paa* Dubois, 1975, respectively.

Voucher specimen: ZSI A13429, ZSI A13430

References: ANDERSON (1971); SCHLEICH & KÄSTLE (2002); OHLER & DUBOIS (2006).

Nanorana liebigii (Günther, 1860) (Figure 8)

Measurements: SVL, male: 53.5–123 mm; female:



Figures 6–11. Amphibians of the Sikkim Himalaya, India. **6.** *Nanorana blanfordii* (SVL 43 mm, male), 27°43'52.94" N, 088°33'7.99" E, 5 June 2013. **7.** *Nanorana gammii* (SVL 72.5 mm, female), 27°24'43.42" N, 088°37'42.35" E, 22 August 12. **8.** *Nanorana liebighii* (SVL 81.3 mm, male), 27°43'23.56" N, 088°33'7.12" E, 16 June 12. **9.** *Hoplobatrachus tigerinus* (SVL 83.5 mm, female), 27°12'26.51" N, 088°39'5.76" E, 11 October 2013. **10.** *Fejervarya nepalensis* (SVL 29 mm, male), 27°19'27.28" N, 088°33'43.78" E, 6 July 2012. **11.** *Fejervarya teraiensis* (SVL 30.2 mm, male), 27°19'28.59" N, 088°33'50.24" E, 10 July 2013.

61.5–117 mm (BOULENGER 1920; DUBOIS 1976). Specimens from Sikkim, male: 55.4–100 mm ($n = 20$); female: 69.6–120.5 mm ($n = 12$).

Diagnostic characters: Head broader than long, depressed. Snout rounded. Tympanum indistinct. Presence of prominent dorsolateral folds. Fingers free, tips rounded. Toe webs slightly incurved. Dorsum smooth, with oblong warts on dorsolateral folds. Upper part olive, brown, or brownish red. Ventral skin is smooth and uniformly whitish.

pectoral and gular region speckled. During the reproductive phase males develop strong hypertrophied arms, spines on the metacarpal tubercle, the first three fingers, the side of the arms and the pectoral region.

References: BOULENGER (1920); OHLER & DUBOIS (2006).

Hoplobatrachus tigerinus (Daudin, 1802) (Figure 9)

Measurements: SVL, male: 77–108 mm; female: 65–162 mm (BOULENGER 1920). Specimens from Sikkim, male:



Figures 12–15. Amphibians of the Sikkim Himalaya, India. **12.** *Megophrys parva* (SVL 39.2 mm, male), 27°22'35.92" N, 088°13'23.88" E, 19 August 2012. **13.** *Megophrys robusta* (SVL 82.2 mm, female), 27°30'25.61" N, 088°31'18.85" E, 28 May 12. **14.** *Scutiger boulengeri* (SVL 48.5 mm, male), 28°01'34.79" N, 088° 42'51.72" E, 7 June 2013. **15.** *Scutiger sikkimensis* (SVL 48 mm, male), 27°43'54.75" N, 088° 33'13.42" E, 5 June 2013.

60.1–73 mm ($n = 5$); female: 63.6–83.5 mm ($n = 7$).

Diagnostic characters: Head pointed, longer than broad. Snout projects slightly over the lower jaw. *Canthus rostralis* rounded. Tympanum distinct $\frac{2}{3}$ the diameter of the eye. Supratympanal fold present. Fingers free, toes completely webbed except the fourth toe. Dorsum smooth, presence of 6–14 longitudinal folds along the back, folds interrupted or continuous. Yellowish green or olive above with dark spots. Ventral side white with dark spots on the throat.

References: BOULENGER (1920); SCHLEICH & KÄSTLE (2002).

Fejervarya nepalensis (Dubois, 1975) (Figure 10)

Measurements: SVL, male: 27–31.5 mm; female: 31.5–40 mm (Dubois, 1975). Specimens from Sikkim, male: 23–27.3 mm ($n = 16$); female: 30–35.5 mm ($n = 18$).

Diagnostic characters: Head pointed from dorsal view and rounded from the side view. Supratympanal fold present from posterior corners of eye to the forelimb insertion. Fingers free, toes $\frac{2}{3}$ -webbed. Dorsum has 4 dorsolateral folds consisting of tubercles. Ventral side smooth. Mid-dorsal line always present, with or without red patches on dorsum. Presence of vocal sacs in males. Lateral side of throat dark in males.

This is a first report of *F. nepalensis* from Sikkim.

Voucher specimen: ZSI A14153.

References: DUBOIS (1975); SCHLEICH & KÄSTLE (2002).

Fejervarya teraiensis (Dubois, 1984) (Figure 11)

Measurements: SVL, male: 49.5 mm; female: 41–48.5 mm (Schleich and Kästle 2002); male: maximum 51 mm; female: maximum 56 mm (Dubois 1975). Specimens from Sikkim, male: 30.2–45 mm ($n = 5$); female: 29–44.3 mm ($n = 3$).

Diagnostic characters: Head pointed. Snout is rounded and slightly projects over the lower jaw. *Canthus rostralis* rounded. The tympanum is rounded, $\frac{1}{2}$ to $\frac{2}{3}$ of the size of the eye and is covered by spots. Fingers free, toes $\frac{2}{3}$ -webbed. Dorsal side with varied patches of red, orange or green. Males with typical W-shaped marking on the throat.

References: SCHLEICH & KÄSTLE (2002); HOWLADER (2011).

Family Megophryidae Bonaparte, 1850

Megophrys parva (Boulenger, 1893) (Figure 12)

Measurements: SVL, male/female: average 31 mm (Nanhoe and Ouboter 1987). Sikkim specimens, males: 37.7–42.7 mm ($n = 6$); female: 35–44.3 mm ($n = 4$).

Diagnostic characters: Head broad and short with distinct angular *canthus rostralis*. Tympanum distinct.

Supratympanal fold distinct and angular. Fingers free, toes have rudimentary webbing. Tips are rounded and slightly thickened. Triangular marking present between the eyes; an hourglass-shaped pattern on the dorsum. Pattern varies between individuals.

References: CHANDA (2002); NANHOE & OUBOTER (1987); BOULENGER (1908).

Voucher specimen: ZSI A13431

Megophrys robusta Boulenger, 1908 (Figure 13)

Measurements: SVL, male/Female: 45–90 mm (Chanda 2002); female: maximum 114 mm (BOULENGER 1908). Specimens from Sikkim, male: 68.1–73 mm ($n = 6$); female: 69–89.1 mm ($n = 7$).

Diagnostic characters: Large frog with distinctly triangular head. *Canthus rostralis* distinct. Distinct tympanum, vertically oval. Digits free with round and flat tips. Iris color brownish red, with lighter margins towards the pupil. Dorsum brownish, with dark markings on the head and back. Body shape, color, and dorsal patterns similar to *Megophrys parva* but *M. robusta* is two or three times larger than *M. parva*.

References: BOULENGER (1908); CHANDA (2002); SCHLEICH & KÄSTLE (2002).

Scutiger boulengeri Bedriaga, 1898 (Figure 14)

Measurements: SVL, male: 46.5–56 mm; female: 52–58.5 mm (NANHOE & OUBOTER 1987). Specimens from Sikkim, male: 45–55.2 mm ($n = 6$); female: 50–61 mm ($n = 8$).

Diagnostic characters: Head flat, wider than long. Snout rounded. Snout tip protrudes beyond lower jaw. *Canthus rostralis* banded. Supratympanal fold present. Tympanum indistinct. Eyes protruding. Pupil vertical. Toes moderately webbed. Males have nuptial spines on fingers 1–3, a pair each of axillary and pectoral nuptial pads. Venter in reproductive males is dotted with numerous small warts with black tips. Similar granules also present near cloaca. Black tips wear off in preserved specimens if not fixed in formalin. Color olive, brownish, or greyish with numerous warts on the dorsal surface, arranged in a longitudinal row. Ventral side yellowish. Dorsal color slightly darker than the body color. Bar-shaped pattern between eyes. Pupil golden with melanophores.

Voucher specimens: ZSI A13421, ZSI A13422

References: NANHOE & OUBOTER (1987); SCHLEICH & KÄSTLE (2002); SUBBA et. al. (2015).

Scutiger sikkimensis Blyth, 1855 (Figure 15)

Measurements: SVL, male: 44–61.5 mm; females: 47–60.5 mm (NANHOE & OUBOTER 1987). Specimens from Sikkim, male: 42.5–62.3 mm ($n = 10$); female: 45.1–67 mm ($n = 13$).

Diagnostic characters: Head wider than long. Snout rounded, slightly protrudes over the lower jaw. Tympanum hidden. Eyes protruding. Pupil vertical. Parotid glands present. Supratympanal fold in contact with the parotoids

and does not reach the upper arm insertion. Toe webbing rudimentary. Males have four rounded-subquadrangular or oval pectoral nuptial pads, two larger midpectoral and two smaller axillary pads. Nuptial spines present on the upper side of fingers I and II and laterally on finger III. Reproductive males develop tiny warts with black tips on sides of head and on anterior of lower jaw, dorsal region of legs, and on ventral region of toes IV and V. Dorsal color in life olive green, brown, or grayish brown, with numerous warts. Dorsal pattern variable. Ventral region yellowish, uniform, and smooth. Pupil golden with melanophores.

Voucher specimen: ZSI A13433

References: NANHOE & OUBOTER (1987); YE et al. (1992); SCHLEICH & KÄSTLE (2002); SUBBA et. al. (2015).

Family Ranidae Batsch, 1796

Amolops formosus (Günther, 1876) (Figure 16)

Measurements: SVL, male: 53 mm; female: 53–75 mm (BOULENGER 1920). Specimen from Sikkim, male: 50.8 mm ($n = 1$).

Diagnostic characters: Head broader than long. *Canthus rostralis* angular and distinct. Tympanum distinct and small. Digital pads on the fingers are larger than those on the toes. Dorsum grass-green, with large distinct dark brown blotches with black margins. Reproductive males with small roundish warts inside the blotches. Dark stripe extends from nostril along the *canthus rostralis* to anterior corner of eye and along supratympanal fold.

References: BOULENGER (1920); YANG (1991); SCHLEICH & KÄSTLE (2002).

Amolops himalayanus (Boulenger, 1888) (Figure 17)

Measurements: SVL, male: 74–75 mm; female: 80–83 mm (BOULENGER 1920). Specimens from Sikkim, male: 75.4–76 mm ($n = 7$); female: 82.3–85.8 mm ($n = 6$).

Diagnostic characters: Head depressed, slightly broader than long or as long as broad. Snout round and projects beyond lower jaw. *Canthus rostralis* rounded. Dorsal skin smooth with small granules on sides and head. Light horny spinules in small clusters, on side of head and base of forelimbs. Ventrums smooth. Dorsally light green to brownish, with dark brown patches without margins. Limbs banded.

Comments: DUBOIS (2004) regarded *A. himalayanus* as a likely synonym of *A. formosus*.

References: BOULENGER (1920); DUBOIS (1974); YANG (1991); CHANDA (2002).

Amolops marmoratus (Blyth, 1855) (Figure 18)

Measurements: SVL, male: 46–90 mm; female: 52–100 mm (BOULENGER 1920). Specimens from Sikkim, male: 40.9–44 mm ($n = 5$); female: 85.52–96.9 mm ($n = 7$).

Diagnostic characters: Head flat, snout pointed and projects over the lower jaw. *Canthus rostralis* distinct and rounded. Tympanum small and distinct. Supratympanal fold present. Digital pads on fingers larger than on toes. Dorsum olive to greenish, marbled with dark gray or brown.



Figures 16–19. Amphibians of the Sikkim Himalaya, India. **16.** *Amolops formosus* (SVL 50.8 mm, male), 27°24'40.90" N, 088°12'2.26" E, 10 August 2012. **Figure 17.** *Amolops himalayanus* (SVL 84.5 mm, female), 27°33'21.11" N, 088°29'2.25" E, 10 May 2012. **18.** *Amolops marmoratus* (SVL 43.2 mm, male), 27°33'21.11" N, 088°29'2.25" E, 5 May 2012. **19.** *Amolops monticola* (SVL 63.3 mm, female), 27°20'1.66" N, 088°33'3.54" E, 9 July 2013.

Dark stripe along *canthus rostralis* and on supratympanal fold. Dark stripes present on dorsal surfaces of limbs.

Voucher specimens: ZSI A13425, ZSI A13426

References: ANDERSON (1871); BOULENGER (1920); NANHOE & OUBOTER (1987); SCHLEICH & KÄSTLE (2002).

Amolops monticola (Anderson, 1871) (Figure 19)

Measurements: SVL, male: 41 mm; female: 65 mm (BOULENGER 1920). Specimens from Sikkim, male: 40.4–50 mm ($n = 10$); female: 59.3–63.3 mm ($n = 14$).

Diagnostic characters: Head longer than broad. *Canthus rostralis* slightly pointed and triangular. Dorsal skin smooth with a pair of dorsolateral folds arising from the back of eye and extending to the cloaca. Tympanum distinct, about $\frac{1}{3}$ the size of eye. Finger and toe tips with discs, webbings complete. Dorsal color varies from yellow to brown, scattered with irregular dark brown spots. A deep bluish band extends from the nostril through eye along the tympanum as far as forelimb insertion. Differs from its congeners by the presence of single pair of folds along the back, smooth skin, and distinctive bands and coloration.

Voucher specimen: ZSI A 13427

References: ANDERSON (1871); AO et al. (2003).

Family Rhacophoridae Hoffman, 1932 (1858)

Polypedates leucomystax (Gravenhorst, 1829) (Figure 20)

Measurements: SVL, male/female: 81 mm (BOULENGER 1890), maximum (sex unknown) 85 mm (SARKAR et al. 1992). Specimens from Sikkim, male: 50.2–52.5 mm ($n = 2$); female: 73.1–75 mm ($n = 4$).

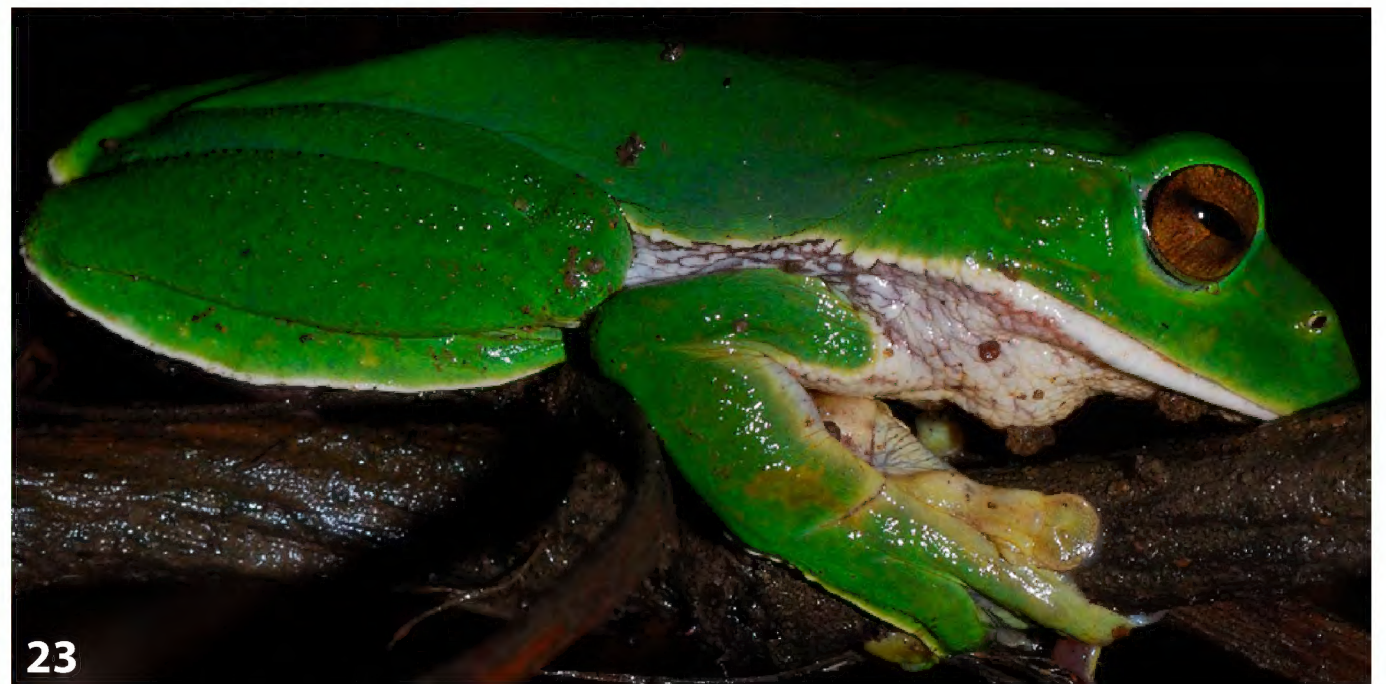
Diagnostic characters: Head as long as broad, large, and triangular. *Canthus rostralis* angular. Dorsal skin of head fused with skull and immovable in adults. Tympanum distinct, $\frac{2}{3}$ diameter of eye. Toes webbed. Finger pads smaller than toe pads. Dorsal side smooth to slightly granular. Upper and lower lips white. Dorsum usually with hourglass-shaped dark mark. Color variable, whitish or yellowish to brownish. Venter smooth and uniformly white or yellowish.

References: BOULENGER (1890); SARKAR et al. (1992); SCHLEICH & KÄSTLE (2002).

Polypedates maculatus (Gray, 1830) (Figure 21)

Measurements: SVL, male: average 57 mm; female: average 89 mm (NANHOE & OUBOTER 1987). Specimens from Sikkim, male: 54.5–55.9 ($n = 3$).

Diagnostic characters: Head with bony arch in temporal region. Skin on head movable. *Canthus rostralis* angular. Tympanum distinct, $\frac{3}{4}$ diameter of eye. Fingers with rudimentary webbing. Toes $\frac{3}{4}$ -webbed. Finger pads larger than toe pads. Dorsum smooth, brownish with darker spots.



Figures 20–23. Amphibians of the Sikkim Himalaya, India. **20.** *Polypedates leucomystax* (SVL 52.5 mm, male), 27°14'59.70" N, 088°11'18.75" E, 10 August 2013. **21.** *Polypedates maculatus* (SVL 55.9 mm, male), 27°32'57.79" N, 088°27'24.57" E, 6 May 2012. **22.** *Raorchestes annandalii* (SVL 18.2 mm, male), 27°20'17.44" N, 088°36'42.28" E, 1 May 2012. **23.** *Rhacophorus maximus* (SVL 99.5 mm, female), 27°09'44.58" N, 088°09'54.10" E, 6 April 2012.

Venter slightly granular and white or yellowish.

References: ANNANDALE (1912); NANHOE & OUBOTER (1987); SCHLEICH & KÄSTLE (2002); SARKAR (2006).

Raorchestes annandalii (Boulenger, 1906) (Figure 22)

Measurements: SVL male/female: 15–20 mm (sex unknown) (SCHLEICH & KÄSTLE 2002). Specimens from Sikkim, male: 17.8–20.3 mm ($n = 21$); female: 19–20.1 mm ($n = 7$).

Diagnostic characters: Small sized frog with anterior and posterior part of the body pointed. Head as long as broad, snout projected beyond the lower jaw. *Canthus rostralis* distinct and rounded. Tympanum small and indistinct. Fingers free, toes minimally webbed. Dorsal and ventral side smooth, with few tubercles on the sides. Dorsal color variable, brownish to greyish olive. Ventral surface yellowish grey to cream, with brown speckles dots or marbling. Broad bar present between the eyes, along *canthus rostralis* and from posterior end of eye to the shoulder. Males with a large, translucent, subgular vocal sac.

References: SCHLEICH & KÄSTLE (2002); SARKAR & RAY (2006); MATHEW & SEN (2010).

Rhacophorus maximus Günther, 1858 (Figure 23)

Measurements: SVL, male: 60–81 mm; females: 104–109 mm (McCANN 1932), male: 74.2 mm; female: 93.5 mm (LUU 2014). Sikkim specimen, female: 99.5 mm ($n = 1$).

Diagnostic characters: Large frog with stocky body. Head flat and broad. *Canthus rostralis* distinct and angular. Tympanum $\frac{2}{3}$ the size of eye. Supratympanal fold present. Fingers $\frac{2}{3}$ -webbed and toes are completely webbed. Adhesive pads on the fingers are larger than on toes. Dorsal region with fine granules; ventral region with coarse granules. Dorsum uniformly green. Ventral color variable, white, violet, or light brown, separated from green color by yellow line.

References: GÜNTHER (1858); BOULENGER (1890); McCANN (1932); LUU (2014).

DISCUSSION

We observed 23 species of amphibians in the field. Although this is fewer than the combined number of reported species from Sikkim, we did add two species previously unreported from the state (Table 1). We were not able to observe the other 20 species in the field despite the literature indicating their presence in Sikkim. The Himalayan salamander,

Tylototriton verrucosus, was reported in Sikkim by BOULENGER (1890), and several authors after him (GAMMII 1928; INGER & DUTTA 1986; WALTNER 1973; SARKAR 1992; CHANDA 2002; JHA & THAPA 2002; MATHEW & SEN 2010). Most of the above references are based on published papers. There are published records and museum specimens of *T. verrucosus* from several localities in Darjeeling (ANNANDALE 1908; CHAUDHURI 1966; DASGUPTA 1990; DEUTI 2007; NAG & VASUDEVAN 2014). The district of Darjeeling, was once part of the independent kingdom of Sikkim and in 1835 was annexed to British India. Even after the annexure, the natural history explorers of that time considered Sikkim and Darjeeling as a single region due to geographic similarity. The Darjeeling hills is separated from Sikkim by the river Teesta and it might be hypothesized that this river acts as a natural barrier for the Himalayan salamander. The presence of Himalayan salamander in Sikkim remains doubtful. Further intensive surveys are required to confirm its presence in Sikkim.

The remaining 19 species which we were not able to observe during our field survey, nor locate the voucher specimens or photos in scientific collections (Zoological Survey of India, Bombay Natural History Society, The Natural History Museum, London) are: *Euphlyctis cyanophlyctis*, *Nanorana ercepeae*, *N. minica*, *N. polunini*, *Oocydozyga borealis*, *Sphaerotheca breviceps*, *Microhyla ornata*, *Megophrys boettgeri*, *M. major*, *Amolops afghanus*, *Clinotarsus alticola*, *Odorana livida*, *Chiromantis simus*, *Polypedates megacephalus*, *Raochestes dubius*, *R. jerdonii*, *R. reinwardtii*, *Ichthyophis glutinosus*, *I. monochrous*, and *Tylototriton verrucosus*. These species are included in the list for reference only (Table 1), and the occurrence of these species in Sikkim is doubtful until evidence of their presence is found.

Thirteen species of amphibians found in Sikkim are endemic to Eastern Himalaya, but there are no amphibians endemic to Sikkim state. Of the 44 species, four are with a Red List category. *Nanorana minica* is categorized as Vulnerable (VU), and *Nanorana annandalii*, *N. ercepeae*, and *N. gammii* are Near Threatened (NT) (IUCN 2015).

This checklist is the first compilation of the amphibian fauna of the state of Sikkim, India, and will provide baseline information for future work on amphibians in this state.

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